Draft

GENERIC VERIFICATION PROTOCOL FOR RETROFIT AIR POLLUTION CONTROL TECHNOLOGIES FOR HIGHWAY AND NON-ROAD USE DIESEL ENGINES

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1.0 INTRODUCTION

1.1 Environmental Technology Verification

The U.S. Environmental Protection Agency (EPA) has instituted the Environmental Technology Verification (ETV) Program to verify the performance of innovative technical solutions to problems that threaten human health or the environment. EPA created the ETV program to substantially accelerate the entrance of new environmental technologies into the domestic and international marketplaces.

ETV supplies technology buyers, developers, consulting engineers, and permitters with high-quality, objective data on the performance of new or improved technologies. This encourages more rapid protection of the environment with better and less expensive approaches.

ETV has established verification efforts in 12 pilot areas. In these pilot programs, EPA utilizes the expertise of verification partners to design efficient processes for conducting performance tests of environmental control technologies. EPA selects its verification partners from the non-profit public and private sectors, including laboratories, state agencies, and universities. Verification partners oversee and report verification activities based on testing that follows protocols developed with input from all major stakeholder/customer groups associated with the technology area.

The ETV goal is to verify the environmental performance characteristics of commercial-ready technologies through the evaluation of objective and quality-assured data so that potential purchasers and permitters are provided with an independent and credible assessment of what they are buying and permitting.

1.2 Air Pollution Control Technology Program

One of the 12 ETV pilot programs is the Air Pollution Control Technology (APCT) program. EPA's verification partner in the APCT program is Research Triangle Institute (RTI), a non-profit contract research organization with headquarters in Research Triangle Park, NC. The APCT program verifies the performance of commercial-ready technologies used to control air pollutant emissions. The emphasis of the APCT program is on technologies for controlling particulate matter, volatile organic compounds, nitrogen oxides (NO_x), and hazardous air pollutants. As the program matures, more technologies may be added.

RTI cooperatively organized and developed the APCT program for verification testing of air pollution control technologies. The APCT program evaluates only those technologies that are ready for the marketplace.

The APCT program develops generic verification protocols and specific test/quality assurance (QA) plans, conducts independent testing of technologies, and prepares verification test reports and statements for broad dissemination. A goal of the APCT program is to have all testing costs ultimately

become self-sustaining, or "privatized," by operating on project-generated income (user fees) and other resources.

1.3 The Mobile Sources Air Pollution Control Technology Task

Control of emissions from mobile sources continues to be of great national importance. Despite considerable progress, the overall goal of clean and healthy air continues to elude much of the country. Unhealthy air pollution levels of criteria pollutants still plague virtually every major city in the United States. This is largely because development and urban sprawl have created new pollution sources and have contributed to a doubling of vehicle travel since 1970. Furthermore, scientists and now the public have become concerned about previously unrecognized environmental threats such as global warming, acid rain and air toxics. Motor vehicles contribute to all these problems. The mobile source provisions of the 1990 Clean Air Act are intended to reduce most vehicle-related pollutants by more than 40 percent.

One important group of mobile source air pollution control initiatives are concerned with highway and non-road diesel engines. The diesel particulate standard for urban buses was reduced in 1993 by 60 percent, from 0.25 to 0.1 gram per brake-horsepower per hour (g/bhp-hr).
The standard, which applies to urban transit buses, dropped to 0.07 g/bhp-hr in 1994 and to 0.05 g/bhp-hr in 1996. New retrofit technologies are being developed to meet these important goals.
In addition, since a NO_x emission level below the level mandated allows the generation of credits or allowances that may be sold on the market, pollution prevention becomes more cost effective, and innovations in less-polluting alternatives and control technology are encouraged. For these reasons, the Stakeholders Advisory Committee (SAC) recommended inclusion of retrofit air pollution control technologies for mobile sources as a priority for verification.

This generic verification protocol provides a template for verification of retrofit air pollution control technologies applied to highway and non-road diesel engines. It is intended to apply to all retrofit technologies, and sets critical data quality goals that are required to support the diesel engine retrofit program and its emission credit allowance provisions. For each specific technology type (eg., add-on oxidation catalytic technologies), specific test/quality assurance (QA) plans will be written to describe a verification test that meets the data quality requirements of this generic protocol for that specific technology type.

This protocol was developed and has been reviewed by a technical panel made up of a broad group of stakeholders who have mobile source control expertise. Technical panel membership is dynamic, and its composition is expected to change over several years as technical emphases change. The APCT program will maintain balance on the panel.

Retrofit mobile source control technologies may be classified as (1) add-on control devices or (2) pollution reduction technologies integral to the engine, or (3) fuel or lubricant additives that require no mechanical changes to engines. Some technologies may be difficult to classify, but generally add-on

technologies are back-end devices that reduce emissions without much effect on the existing source. Examples include add-on filtration devices for particulate matter (PM) control and add-on catalytic oxidizers. Fuel and lubricant additives are a special case of add-on technologies that require special scrutiny because they potentially introduce new components to the emissions stream. Add-on technologies can be evaluated by measuring emissions with and without the control technology in use to determine efficiency, or only in use to determine emission concentrations. Integral technologies, such as engine modifications, become integral to the source. In general they cannot be evaluated separately from their implementation on the source, and their performance is measured as an emission concentration.

These differences between types of technologies will result in the need to prepare test/QA plans that are suitable for each technology grouping. Other use- or technology-specific information may also need to be addressed in the test/QA plan which provides a detailed plan to implement each verification test and document test procedures. In general, test/QA plans will not be reviewed by the entire technical panel. However, because specific technology areas may require special expertise or emphasis, input and review will be obtained from an ad hoc subcommittee of the technical panel and/or outside experts when deemed appropriate. Test results will be presented as verification reports and verification statements.

1.4 Quality Management Documents

Management and testing within the Retrofit Air Pollution Control Technologies for Highway and Non-road Use Diesel Engines Task are performed in accordance with procedures and protocols defined by a series of quality management documents. These include EPA's Quality and Management Plan (ETV QMP) for the overall ETV program (EPA, 1998a), the Quality Management Plan (QMP) for the overall APCT program (RTI, 1998), the Generic Verification Protocol for NO_x Control Technologies (this document), and test/QA plans prepared by the test organizations.

EPA's ETV QMP lays out the definitions, procedures, processes, inter-organizational relationships, and outputs that will ensure the quality of both the data and the programmatic elements of ETV. Part A of the ETV QMP contains the specifications and guidelines that are applicable to common or routine quality management functions and activities necessary to support the ETV program. Part B of the ETV QMP contains the specifications and guidelines that apply to test-specific environmental activities involving the generation, collection, analysis, evaluation, and reporting of test data.

APCT's QMP describes the quality systems in place for the overall APCT program. It was prepared by RTI and approved by EPA. Among other quality management items, it defines what must be covered in the generic verification protocols and test/QA plans for technologies undergoing verification testing.

Generic Verification Protocols are prepared to describe the overall procedures to be used

for testing a type of technology and define the critical data quality objectives (DQOs). The document herein is the generic verification protocol for retrofit air pollution control technologies for highway and non-road use diesel engines. It was written by the APCT program with input from a technical panel and approved by EPA.

Test/QA plans are prepared by the test organization. Because multiple testing organizations will be conducting the tests and the desirability to ensure comparability, the APCT Program will develop a prototype test/QA plan for each type of technology. This prototype may be customized in minor ways by the testing organization to meet their specific testing arrangements. However, modifications that the APCT program feels will compromise comparability between labs will not be approved. The test/QA plan describes, in detail, how the testing organization will implement and meet the requirements of the generic verification protocol. The test/QA plan also sets DQOs for non-critical measurements that are specific to the technology type. The test/QA plan addresses issues such as the test organization's management organization, test schedule, documentation, analytical methods, data collection requirements, calibration, and traceability, and it specifies the QA and quality control (QC) requirements for obtaining verification data of sufficient quantity and quality to satisfy the DQOs of the generic verification protocol. Section 10 of this generic verification protocol addresses requirements for the test/QA plan.

2.0 OBJECTIVE AND SCOPE

2.1 Objective

The objective of the Retrofit Air Pollution Control Technologies for Highway and Non-road Use Diesel Engines Task is to verify, with high data quality, the performance of retrofit air pollution control technologies that are applied to highway and off-road diesel mobile sources. The control technologies will be verified within a specified range of applicability, and verification reports and statements will be produced for dissemination to the public.

2.2 Scope

Testing will be performed on add-on or integral air pollution control devices that are intended for use on mobile diesel emissions sources. The pollutants of primary interest are NO_x and PM. Still important, though not critical, are emissions of hydrocarbons ((HC), carbon monoxide (CO), and carbon dioxide (CO_2). The verification tests will also gather information and data for evaluating the performance of the technologies and the technologies' associated environmental impacts and efficiency impacts.

This verification program is explicitly based on the Federal Test Procedures (FTPs) for Highway (CFR 86) and Off-Road (CFR 89) use diesel engines. The FTPs are utilized by manufacturers to certify their engines as meeting Federal emissions guidelines and as such set the standard of value for mobile source testing. Also fundamental to this verification program is providing information needed for manufacturers to participate in the Voluntary retrofit program (REF) and its associated use of emissions credits. Credit determinations will be made by EPA's Office of Transportation Air Quality; the ETV program will provide, if possible, the data needed to make that determination.

2.2.1 On-Highway Engines

Testing of technology intended to control emissions from on-highway diesel engines will be conducted generally within the requirements of 40 CFR, part 86, subpart N. The primary emissions measurements will be of NOx, PM, HC, CO, CO_2. The smoke test (40 CFR, part 86, subpart I) will be required. The hot-start portion of the FTP will be sufficient in general; however, development of the test/QA plan for each type of technology must consider whether cold start testing would be important.

The tests will be conducted on a group of test engines that represents the most likely engine technologies to be retrofitted. Engine technologies to be considered include: mechanical injection, electronic injection, turbo-charged, naturally-aspirated, aftercooled, without aftercooling, water-cooled, air-cooled, two-stroke, and four stroke. These technology types represent generic technology and usage attributes and are independent of any particular manufacturer.

Each engine in the test group will be loaded by a dynamometer to follow a specified test cycle. The dynamometer test cycle will include Euro III testing as used in the European steady-state engine certification test (REF). This test consists of 13 steady-state modes simulating a broad range of highway operating conditions.

2.2.2 Off-Road Engines

Testing of technology intended to control emissions from off-road diesel engines will be conducted generally within the requirements of 40 CFR, part 89, subpart E. The primary emissions measurements will be of NOx, PM, HC, CO, CO_2. The smoke test (40 CFR, Part 89, subpart I) will be required. Testing will be conducted using the test procedures specific to a particular engine group (e.g., C-1 {5-mode}, D-2 {8-mode}, G-2 {6-mode}, or E-3 { 4-mode} as specified in 40 CFR, Part 89.) The results of the verification would be applicable to that engine group tested..

The tests will be conducted on a group of test engines that represents the most likely engine technologies to be retrofitted. Engine technologies to be considered include: mechanical injection, electronic injection, turbo-charged, naturally-aspirated, aftercooled, without aftercooling, water-cooled, air-cooled, two-stroke, and four stroke. These technology types represent generic technology and usage attributes and are independent of any particular manufacturer.

Each engine in the test group will be loaded by a dynamometer to follow a specified test cycle. The dynamometer test cycle will include Euro III testing as used in the European steady-state engine certification test (REF). This test consists of 13 steady-state modes simulating a broad range of highway operating conditions.

2.2.3 Control Technologies

This generic verification protocol is specifically intended to include a broad spectrum of air pollution control technologies, including:

- Oxidation catalysts,
- Engine modifications and rebuild kits,
- Fuel-borne catalysts,
- Fuel additives,
- Filters, and
- Lubricants and lubricant additives.

2.3 Data Quality Objectives (DQOs)

The critical measurements for this verification are the emission concentration of NO_x and PM. Control technology performance in regard to either may be expressed as a removal efficiency or as an absolute emission concentration. Critical data quality objectives for both are presented below based on the requirements of the retrofit program emissions credit decision. The data quality objectives for emissions of hydrocarbons ((HC), carbon monoxide (CO), and carbon dioxide (CO_2) are not critical and will be set in the test/QA plan.

For the NO_x emission concentration, the test/QA plan will include measurements sufficient to allow determination of the technology's overall NO_x emission concentration to within ±??% of the mean emission concentration above ?? ppmv, within ±???% below ?? and above ?? ppmv, and within ±??% below ? ppmv. The DQO is to be computed as the half-width of the 95% confidence interval of the mean divided by the mean, or, equivalently, as the product of the standard error of the mean and the appropriate Students-t value divided by the mean. All measurements apply within the performance envelope being verified. The NO_x emission concentration will be measured using the method in 40CFR Parts 86 or 89 for Highway and off-road use engines, respectively. The method in 40CFR Parts 86 or 89 is the reference method and will be taken to be without bias.

[Paragraph addressing number of tests required to achieve the DQO]

[Set Critical DQO for PM]

[Paragraph addressing number of tests required to achieve the DQO]

Should the verification test be conducted and the critical NO_x DQO not be met due to excessive data variability, the verification partner and testing organization will present the data to the vendor and discuss the relative merit of various options. The two primary options will be either to continue the test to obtain additional data, with resulting increases in cost to all parties, or to terminate the test and report the data obtained.

Specific DQOs will also be included in each test/QA plan for all measurements of NOx, PM, HC, CO, CO2, and engine operating parameters that are reasonably expected to affect emissions. Measurement DQOs will be set after inspection in the test/QA plan. The potential for measurement bias should be evaluated by inspection and experience. QC procedures and technical assessments will evaluate measurement bias during verification testing for those measurement parameters where the potential for bias has been identified.

The uncertainties outlined above require that the DQOs expressed in this draft generic verification protocol be reviewed following completion of the first tests and analysis of the results. The DQOs may need to be revised for the final version of this document.

3.0 VERIFICATION TESTING RESPONSIBILITIES

This verification testing program is conducted by the APCT program, under the sponsorship of the EPA, with the participation of technology manufacturers/vendors. The APCT program is operated under a cooperative agreement by the Research Triangle Institute (RTI), the ETV verification partner. RTI's role as verification partner is to provide technical and administrative leadership and either conduct or manage the conduct of verification testing and reporting. Various subcontractors have roles in the APCT program under RTI's management. Site-specific verification test/QA plans are prepared to meet the requirements of generic verification protocols, such as this one, approved by the APCT program.

The test/QA plan will include a figure that presents the test program organization and major lines of communication. Based on the figure, the plan will identify the testing organization and any other test participants. The plan will provide a table listing the name, affiliation, mailing address, telephone and fax numbers, and e-mail address of each participant. The organizations involved in verification of mobile diesel air pollution control technologies are the EPA, RTI, the testing laboratory, and the technology manufacturer/vendor.

The primary responsibilities for each organization involved in the test program are:

- The EPA, following its procedures for ETV, reviews and approves generic verification protocols, test/QA plans, verification reports, and verification statements.
- The APCT program prepares the generic verification protocol, provides oversight of the testing organization, prepares the test/QA plans, and jointly with EPA reviews and approves the verification test reports and verification statements.
- The testing organization will coordinate test details and schedules with the manufacturers/vendors, conduct the tests, and prepare and revise draft test reports and draft verification statements. The testing organization QA staff will be responsible for conducting internal QA on test/QA plans and reports.
- EPA and/or APCT program QA staff will conduct technical assessments of the test organization's tests and products.
- The technology manufacturers/vendors are responsible for providing complete, commercial-ready equipment for verification testing; providing logistical and technical support, as required; and assisting the testing organization with operation and monitoring of the equipment during the verification testing. Each manufacturer/vendor will be responsible for bearing a portion of the test cost as defined by a contract or letter of agreement with RTI as the APCT program verification partner.

4.0 TECHNOLOGY CAPABILITIES AND DESCRIPTION

The test/QA plan must contain a statement by the technology manufacturer/vendor regarding applicability of the technology.

The test/QA plan will also describe the technology to be verified. The description, provided by the technology manufacturer/vendor, must include: technology name, model number, manufacturer's name and address, electrical service requirements, serial number or other unique identification, warning and caution statements, capacity or output rate, and other information necessary to describe the specific technology. The performance guarantee coupled with operating conditions will express the actual installation size if design parameters are proprietary. The test/QA plan will also include a draft verification statement, based on Appendix D, and be customized to the specific technology being verified and measurements being made.

Other descriptive information the vendor may provide for inclusion in the verification report can address the logistical, human, and economic resources necessary to install and operate the technology. Some examples are:

Installation requirements:
- footprint (space) occupied,
- installation time,
- modifications,
- startup and shakedown time,
- ancillary equipment, if any, and
- any other special requirements.

Operator qualifications / training / safety:
- qualifications needed to operate and service the technology,
- amount and type of training needed for operation and maintenance, and
- special safety considerations.

Maintenance requirements
- recommended maintenance procedures and
- spare parts and supplies

Operation:
- labor requirements,
- chemicals and other consumable feedstocks and reactants,
- energy requirements, and
- ancillary equipment requirements.

Secondary emissions:
- air,
- water, and
- solid waste.

Technology's life expectancy

5.0 TEST PROGRAM

1. Testing shall be conducted in accordance with 40 CFR, part 86, subpart N (Table 1) Measure emissions of HC, NOx, CO, CO2 & PM

2. Test cycle for on-hwy engines will include Euro III testing based on the European steady-state engine certification test. The test consists of 13 steady-state modes covering a broad range of hwy-type operating conditions.

3. Smoke test required

4. Hot-start portion of FTP required for product evaluation(cold start testing not required for general verification but may be required if a particular concern arises relative to a specific technology

5. Testing including evaluation of toxic emissions may be necessary in cases where there is a concern the technology may result in an increase of this pollutants.

II. Off- Road Engines

Testing shall be conducted in accordance with 40 CFR, part 89, subpart E (Table 2).

1. Measure emissions of HC, NOx, CO, CO2 & PM using the appropriate engine test cycle as per Section 89.410.

2. Test cycle substitution as per Section 89.410(a)(5) is allowed.

3. Smoke testing required

III. Evaluation Protocol

1. Testing - Retrofit equipment will be tested using appropriate test cycle(s) to demonstrate reductions for regulated pollutant (see Tables 1 and 2).

a.. For on-hwy engines, the standard test will be based on the hot cycle portion of the on-hwy FTP for HD engines as specified in part 86.

b. For off-road engines conduct testing using specific test procedures for a particular engine group (C-1{5-mode}, D-2{8-mode},G-2{6-mode} or E-3{4-mode} cycle) as specified in part 89. The results of this test would then be used to predict the effectiveness of the equipment

that the engine group.

2. Baseline Test- Perform baseline test without device/retrofit equipment. Prior to test, engine will undergo engine MAP as per CFR requirements. Baseline test will include smoke test.
3. Evaluation Test - Perform (2) tests with the equipment/device installed. Results for the (2) tests with the equipment in-place will be averaged. If the results of the two tests conducted with the equipment in-place vary significantly, it will be necessary to evaluate the cause of the variability before the results are accepted. Smoke test will be performed. When testing of the equipment is complete, the equipment will be removed from the engine. The engine will be then be conditioned for testing additional retrofit equipment.

4. Prior to testing, each retrofit technology shall be aged/de-greened. The equipment should be de-greened for a period of 125 hours prior to submission for evaluation. De-greening should occur on an engine that will be covered by the retrofit program. De-greening may occur in the laboratory setting or on an engine in-use in field operations. The equipment manufacturer may propose an alternate aging period/process, that allows for stabilization of the retrofit technology.

5. Regeneration cycle - If the equipment periodically goes through a regenerative process, sufficient test cycles must be run until a test cycle includes a "regeneration" episode. The results of all test cycles run (including the regenerative cycle) shall then be averaged.

6. After treatment technology will be tested on the engine family or engine application believed to have the minimum reduction capabilities for the group. For example, the minimal catalyst sizing and precious metal loading for an engine grouping.

7. Durability- The equipment manufacturer will submit to durability testing of the equipment. Tests will be conducted on the engines for which the original verification tests were conducted (if available) . The equipment aging process may occur on an engine dynomometer or on an actual in-use engine. In-use aging should occur in conjunction with an engine and in-use application for which the technology is typically intended. Testing will be performed after the equipment has been aged for 25% of the retrofits equipments useful life as per the manufacturer. Results from the durability tests will be projected to the end of the equipments useful life to determine the effectiveness of the equipment to reduce pollutants over it's lifetime. The equipment manufacturer may provide the aged equipment for durability testing in conjunction with the verification testing to be performed.. It is noted that additional durability tests may be required if concerns arise in-use.

8. Test Fuel -

    - The diesel test fuel should meet the EPA specifications outlined in 40 CFR

§86.1313-98 with the exception of the sulfur content. Because the performance and durability of many types of diesel retrofit technology are affected by the sulfur content of the diesel fuel, manufacturers should specify the maximum sulfur level of the fuel for which their technologies are designed.

- The sulfur content of the diesel test fuel should be no less than 66 percent of the stated maximum sulfur content.
- Other test fuels should meet the applicable EPA specifications outlined in 40CFR §86.1313.

Retrofit technology will be tested, using the procedures outlined above, to quantify their affect on the following regulated pollutants: HC, CO, NOx and PM

Toxic Emissions. If EPA has reason to believe that there may be an increase in toxic emissions as a result of the retrofit technology application then the manufacturer may be asked to analyze the exhaust for suspect toxic emissions.

Engine Performance/Power

Fuel Consumption

Backpressure (Retrofit should be within the engine manufacturer's specified maximum limit. Also comparison of retrofit backpressure to the baseline backpressure).will result from the observed changes in the backpressure.)

Test Engines

Test engine grouping

Central to the verification process is the demonstration of a given retrofit technology's emission reduction capabilities. These emissions reductions must be demonstrated on a sample of test engines which represents the range of engines considered most likely to be retrofitted (on-hwy, non-road & marine). The test-engine groupings consist of an array of engines distinguished by engine technology and the intended application of the engine as follows:

A retrofit manufacturer must demonstrate its technology on engines from the test-engine pool to verify the technology for each engine grouping. These groupings are intended to represent generic technology and usage attributes independent of a particular engine manufacturer. A retrofit manufacturer may request that these categories be consolidated based on engineering rationale. For example, a retrofit kit may be applicable to both electronically and mechanically controlled engines. The retrofit manufacturer may provide

information which justifies why the emissions reductions demonstrated with one design represents the other. Furthermore, these categories will collapse automatically. For example, most electronically controlled engines are likely to employ turbocharging and aftercooling.

Engine Selection

Engine Technology	Application		
	HeavyHDE/LargeOff--Road/Marine	Medium HDE and Off-Road	Light HDE and Off-Road
Mechanical Injection			
Electronic Injection			
Turbocharged			
Naturally Aspirated			
Aftercooled			
No Aftercooling			
Water Cooled			
Air Cooled			
Two Stroke			
Four Stroke			

Engine Selection:

Test engines chosen to represent the broad population of engines to which the equipment will apply.

6.0 REPORTING AND DOCUMENTATION

This section describes the procedures for reporting data in the Verification Test Report and the verification statement. The specifics of what data must be included and the format in which the data must be included are addressed in this section (e.g., QA/QC summary forms, raw data collected, photographs / slides / video tapes). The verification test report for each technology is expected to be about 50-70 pages in length and will include the verification statement as an addendum at the front of the report. The verification statement is a two- to five-page summary of the verification results. A preliminary draft is attached as Appendix D. The Verification Test Report, including the draft verification statement, will be prepared by the testing organization. Both will be reviewed by the APCT program before being submitted to EPA for review and approval as specified in the ETV QMP. The verification statement is approved by the APCT program as well as EPA.

6.1 Reports

The testing organization will prepare a Verification Test Report that thoroughly describes and documents the verification testing that was conducted and the results of that testing. The test report shall include the following topics:

- Verification statement,
- Introduction,
- Description and identification of product tested,
- Procedures and methods used in testing,
- Statement of operating range over which the test was conducted;
- Summary and discussion of results:
  - < Support verification statement,
  - < Explain and document necessary deviations from test plan,
  - < Discussion of QA and QA statement;
- Conclusions and recommendations;
- References; and
- Appendices:
  - < QA/QC activities and results,
  - < Raw test data, and
  - < Equipment calibration results.

The test/QA plan must include example tables of how the data will be summarized and reported. The measurement data are to be presented in a format that allows a reviewer to easily determine whether the testing has met the data quality objectives.

The verification statement will include the following:

- APCT manufacturer/vendor information,

- APCT vendor claim of performance,
- Summary of verification test program,
- Results of the verification test,
- Any limitations of the verification results, and
- Brief QA statement.

Review and approval of the draft verification report and statement are as described in Section 3.0. A draft verification statement is attached as Appendix D.

6.2 Data Reduction

Data from measurements made as part of the verification test will be reported in the following units:

- The units stipulated in the method followed,
- SI units, or
- English units.

The ???? emission rate from the APCT verification test will be reported in parts per million by volume (ppmv).

A unit conversion table from British Engineering Units to SI units will be provided.

6.3 Statistical Analysis of Verification Data

This section describes the statistical analysis of verification data using a physically reasonable hypothetical data set.

[Might want to do something like this]

7.0 DISSEMINATION OF VERIFICATION REPORTS AND STATEMENTS

After a product has been tested and the draft report and verification statement received from the testing organization, the APCT program will send a draft of both to the manufacturer/ vendor for review prior to submission to EPA and release to the public. This gives the manufacturer/vendor an opportunity to review the results, test methodology, and report terminology while the drafts remain working documents and are not publically accessible. The manufacturer/vendor may submit comments and revisions on the draft statement and report to the APCT program. The APCT program will consider these comments and may suggest revisions of its own. Revisions will be made by the testing organization. The revised verification report and verification statement will be returned to the manufacturer/vendor for final review. Alternatives available to the manufacturer in the case of unsatisfactory performance (see Section 8.0) must be exercised at this time.

After final review by the manufacturer/vendor and review by the APCT program, the draft final verification report and statement will be submitted to EPA for review and approval. Following approval, several copies of the verification report will be provided to the manufacturer/vendor. Distribution of the final verification report, if desired, is at the manufacturer/vendor's discretion and responsibility.

Verification statements will be posted on the ETV web site for public access without restriction. An original signed verification statement will be provided to the manufacturer/ vendor of the control technology.

8.0 MANUFACTURER/VENDOR'S OPTIONS IF A TECHNOLOGY PERFORMS BELOW EXPECTATIONS

ETV is not a technology research and development program; technologies submitted for verification are to be commercial-ready and with well-understood performance. In the event that a technology fails to meet the manufacturer's expectations, the manufacturer/vendor has two alternatives. The first recourse is to simply request that a verification statement not be issued. However, verification tests that are funded partially by EPA will always be in the public domain. Verification reports will be written for publicly funded tests, and these will be available from EPA for review by the public regardless of a request not to issue a verification statement.

As a second alternative for unfortunate situations that might arise, the APCT program will allow manufacturer/vendors to "re-purchase" the test by paying the APCT program for its full cost (defined below) up to the time the decision is made to terminate and re-purchase. Exercising this option results in the verification test's being a private transaction, and no government funds will have been expended to support the work, so that the results and report become the property of the manufacturer/vendor. The full cost of a test is defined as all costs incurred by the APCT program and its subcontractors that are associated directly with the verification test. For example, test/QA plan development, the verification test, data analysis, on- and off-site management, QA review and audit, and preparation of verification reports and statements are all elements of the full cost of a

verification test. These alternatives will be described in contractual documents between the APCT and manufacturer/vendors.

The manufacturer may improve the product and resubmit it under a new model identification for verification testing. Verification statements for tests of the new product will be issued as they are processed by the APCT program and EPA (except that the results for several identical tests performed in rapid succession will all be released at the same time.)

9.0 LIMITATIONS ON TESTING AND REPORTING

To avoid having multiple ETV reports for the same product and to maintain the verification testing as a cooperative effort with manufacturer/vendors, the following restrictions apply to verification testing under this protocol:

- Manufacturer/vendors may submit only their own products for testing; manufacturer/vendors may not submit control devices from other manufacturers for verification testing.
- For a given product (e.g., brand and model), APCT policy is that only one ETV verification report and statement will be issued for any single application.
- Air pollution control technology frequently performs differently in different applications. Manufacturer/vendors may request additional tests of essentially identical technology if it is being applied to pollution sources that are clearly different from those for which verifications have been obtained.

10.0 REQUIREMENTS FOR TEST/QA PLAN

10.1 Quality Management

All testing organizations participating in the Retrofit Air Pollution Control Technologies for Highway and Non-road Use Diesel Engines Task program must meet the QA/QC requirements defined below and have an adequate quality system to manage the quality of work performed. Documentation and records management must be performed according to the *ETV Quality and Management Plan for the Pilot Period (1995-2000)* (ETV QMP, EPA, 1998a.) Testing organizations must also perform assessments and allow audits by the APCT program (headed by the APCT QA Officer) and EPA corresponding to those in Section 11.

All testing organizations participating in the Retrofit Air Pollution Control Technologies for Highway and Non-road Use Diesel Engines Program must have an ISO 9000-accredited (ISO, 1994) or ANSI E4-compliant (ANSI, 1994) quality system and an EPA- or APCT program-approved QMP. The APCT program will approve the QMP of the testing organization.

10.2 Quality Assurance (QA)

All verification testing will be done following an approved test/QA plan that meets *EPA Requirements for Quality Assurance Project Plans for Environmental Data Operations* (EPA 1998c) and Part B, Section 2.2.2 of EPA's ETV QMP (EPA, 1998a). These documents establish the requirements for test/QA plans and the common guidance document, *Guidance for Quality Assurance Project Plans* (EPA, 1998b), provides guidance on how to meet these requirements. The APCT Quality Management Plan (RTI, 1998) implements this guidance for the APCT program. The test/QA plan must describe how the methods described in Appendix A of this generic verification protocol will be implemented by the testing organization and the steps the testing organization will take to ensure acceptable data quality in the test results. Any needed standard operating procedures (SOPs) will be developed in accordance with *Guidance for the Preparation of Standard Operating Procedures (SOPs) for Quality Related Documents* (EPA, 1995.)

The testing organization must prepare a test/QA plan and submit it for approval by the APCT program. The test/QA plan must be approved before the test organization can begin verification testing.

A test/QA plan contains the following elements. If specific elements are not included, an explanation for not including them must be provided.

- Title and approval sheet;
- Table of contents, distribution list;
- Test description, test objectives;
- Identification of the critical measurements, data quality objectives (DQOs) and indicators, test schedule, and milestones;
- Organization of test team and responsibilities of members of that team;
- Documentation and records;
- Test design;
- Sampling procedures;
- Sample handling and custody;
- Analytical procedures;
- Test-specific procedures for assessing data quality indicators;
- Calibrations and frequency;
- Data acquisition and data management procedures;
- Internal systems and performance audits;
- Corrective action procedures;
- Assessment reports to EPA;
- Data reduction, data review, data validation, and data reporting procedures;
- Reporting of data quality indicators for critical measurements;
- Limitations of the data; and

- Any deviations from methods from this generic verification protocol.

10.3 Additional Requirements To Be Included in the Test/QA Plan

The test/QA plan must include a diagram and description of the extractive gaseous measurement system to be used for the testing and a list of the reference analyzers and measurement ranges to be used for quantifying the gaseous concentrations. Additional analyzers (CO and THC) in the sampling system diagram must also be included, as well as a list of the reference analyzers and measurement ranges to be used for quantifying CO and THC concentrations.

The test/QA plan must include a schematic of all sample and test locations, including the inlet and outlet to the technology sampling locations. The location of flow disturbances and the upstream and downstream distances from the sampling ports to those flow disturbances must be noted. The number of traverse points that will be sampled must be provided.

The test/QA plan must include the appropriately detailed descriptions of all measuring devices that will be used during the test. These measurements are expected to include those listed in Table 2 and any additional measurements identified as required during site visits and consideration of the test site.

The test/QA plan must explain the specific techniques to be used for monitoring process conditions appropriately for the source being tested. It must also note the techniques that will be used to estimate any other operational parameters.

11.0 ASSESSMENT AND RESPONSE

The APCT program and/or EPA will conduct assessments to determine the testing organization's compliance with its test/QA plan. The requirement to conduct assessments is specified in EPA's *Quality and Management Plan for the Pilot Period (1995 - 2000)* (EPA, 1998a), and in RTI's QMP (RTI, 1998.) EPA will assess RTI's compliance with RTI's test/QA plans. RTI will assess the compliance of other organizations with their test/QA plans. The assessments will be conducted according to *Guidance on Technical Assessments for Environmental Data Operations* (EPA, 1999.)

11.1 Assessment Types

Technical systems audit - Qualitative on-site audit of the physical setup of the test. The auditors determine the compliance of testing personnel with the test/QA plan.

Performance evaluation audit - Quantitative audit in which measurement data are independently obtained and compared with routinely obtained data to evaluate the accuracy

(bias and precision) of a measurement system.

Audit of data quality - Qualitative and quantitative audit in which data and data handling are reviewed and data quality and data usability are assessed.

11.2 Assessment Frequency

Activities performed during technology verification performance operations that affect the quality of the data shall be assessed regularly, and the findings reported to management to ensure that the requirements stated in the generic verification protocols and the test/QA plans are being implemented as prescribed.

The types and minimum frequency of assessments for the ETV Program are listed in Part A Section 9.0 of EPA's *Quality and Management Plan for the Pilot Period (1995 - 2000)*. Tests conducted during the APCT program will have at a minimum the following types and numbers of assessments:

1. Technical systems audits – self-assessments for the test as provided for in the test/QA plan and independent assessments. Two will be conducted for the APCT program.
2. Performance evaluation audits – self-assessments, as applicable, for each test as provided in the test/QA plan and independent assessments, as applicable for each different technology verified by the APCT program.
3. Audits of data quality – self-assessments of at least 10% of all the verification data; and independent assessment, as applicable for the APCT program.

The independent assessments of tests conducted by RTI will be performed by EPA. The independent assessments of other organizations will be by RTI.

11.3 Response to Assessment

Appropriate corrective actions shall be taken and their adequacy verified and documented in response to the findings of the assessments. Data found to have been taken from non-conforming technology shall be evaluated to determine its impact on the quality of the required data. The impact and the action taken shall be documented. Assessments are conducted according to procedures contained in the APCT QMP. Findings are provided in audit reports. Responses by the testing company to adverse findings are required within 10 working days of receiving the audit report. Followup by the auditors and documentation of responses are required.

12.0 SAFETY MEASURES

12.1 Safety Responsibilities

The test company's project leader is responsible for ensuring compliance with all applicable occupational health and safety requirements. Each individual staff member is expected to follow the requirements and identify personnel who deviate from them and report such action to their supervisor.

12.2 Safety Program

The test company must maintain a comprehensive safety program and ensure that all test personnel are familiar with and follow it.

13.0 REFERENCES

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APPENDIX D: EXAMPLE VERIFICATION STATEMENT

Appendix D is an example verification statement for a generic NO_x control technology. The significant parameters, which were discussed in Section 5.1.4, are identified in this example only by the letters A, B, and C. This generic verification statement is intended only to show the form of a verification statement. It will require modification for each technology verified, depending on the details of that technology's design, construction, and operation. The test/QA plan written for each test will include a draft verification statement customized for the technology actually being tested. The text of that specific verification statement will address the significant parameters that actually apply to the technology tested.

THE ENVIRONMENTAL TECHNOLOGY VERIFICATION PROGRAM

U.S. Environmental Protection Agency

Research Triangle Institute

ETV Joint Verification Statement

TECHNOLOGY TYPE:	**NO_x AIR POLLUTION CONTROL TECHNOLOGY**		
APPLICATION:	**CONTROL OF NO_x EMISSIONS FROM COMBUSTION SOURCES USING XXX TECHNOLOGY**		
TECHNOLOGY NAME:	**TECHNOLOGY NAME**		
COMPANY:	**COMPANY NAME**		
ADDRESS:	**ADDRESS** **CITY, STATE ZIP**	**PHONE:** **FAX:**	**(000) 000-0000** **(000) 000-0000**
WEB SITE:	**http://www.company.com**		

The U.S. Environmental Protection Agency (EPA) has created the Environmental Technology Verification (ETV) Program to facilitate the deployment of innovative or improved environmental technologies through performance verification and dissemination of information. The goal of the ETV Program is to further environmental protection by substantially accelerating the acceptance and use of improved and cost-effective technologies. ETV seeks to achieve this goal by providing high quality, peer reviewed data on technology performance to those involved in the design, distribution, financing, permitting, purchase, and use of environmental technologies.

ETV works in partnership with recognized standards and testing organizations; stakeholder groups which consist of buyers, vendor organizations, permitters, and other interested parties; with the full participation of individual technology developers. The program evaluates the performance of innovative technologies by developing test plans that are responsive to the needs of stakeholders, conducting field or laboratory tests (as appropriate), collecting and analyzing data, and preparing peer reviewed reports. All evaluations are conducted in accordance with rigorous quality assurance protocols to ensure that data of known and adequate quality are generated and that the results are defensible.

The Air Pollution Control Technology (APCT) program, one of 12 technology areas under ETV, is operated by the Research Triangle Institute (RTI), in cooperation with EPA's National Risk Management Research Laboratory. The APCT program has evaluated the performance of a NO_x control technology utilizing XXX TECHNOLOGY for stationary combustion sources, TECHNOLOGY NAME.

VERIFICATION TEST DESCRIPTION

All tests were performed in accordance with general guidance given by the APCT program "Generic Verification Protocol for NO_x Control Technologies for Stationary Combustion Sources" and the specific technology test plan "Verification Test/QA Plan for TECHNOLOGY NAME". These documents include requirements for quality management, quality assurance, procedures for product selection, auditing of the test laboratories, and test reporting format.

The NO_x Emission Control Technology was tested as installed and operating at a field test site using stack test methods. NO_x concentrations were measured using continuous emissions monitors (CEMs) following EPA Method 7E. Other gaseous emissions were monitored using the applicable EPA test method. Other process variables were monitored using calibrated plant instrumentation.

Tests were conducted to meet primary quality assurance goals of a 95% confidence interval with a width of ±5% or less of the mean NO_x emission concentration for concentrations above 5 ppmv (±20% for emission concentrations below 5 ppmv). The verification test is valid only for the stated performance envelope of Parameters A, B, and C. *(Three parameters have been assumed for this example verification statement. More or less may be required, depending on the technology being verified.)*

A single test run consisted of setting the primary process variables A, B, and C, allowing the process to reach steady-state, and then measuring outlet NO_x concentration over a half-hour steady-state process condition. The test design was a 2 x 2 x 2 factorial using two levels of A, B, and C. The limits of the performance envelope within which the verification is valid are set by the values of these independent variables, as shown in Table D-1.

Table D-1. Example Verification Test Performance Envelope

	Parameter A	**Parameter B**	**Parameter C**
Low	a_l	b_l	c_l
High	a_h	b_h	c_h

In addition to outlet NO_x concentration and the primary process variables, a number of other emissions of importance for the NO_x control technology were also measured using EPA standard methods, and the energy use rates, staffing, maintenance requirements, and similar issues were noted qualitatively.

TECHNOLOGY DESCRIPTION

This verification statement is applicable to the TECHNOLOGY NAME (to include model number and other identifying information as needed) ....
....
....
....
....

Control of these other pollutants is not a topic included in this generic verification protocol.

This verification statement covers application of TECHNOLOGY NAME to small- and medium-sized stationary combustion sources fueled by natural gas. TECHNOLOGY NAME is characterized by .... *(Descriptive language provided by technology vendor.)*............ ....

VENDOR'S STATEMENT OF PERFORMANCE

TECHNOLOGY NAME is capable of achieving a NO_x emission concentration of _______ ppmv when operated at a Parameter A value*(s)* of _____ and [specify process operating conditions] and of controlling NO_x emissions to below _______ ppmv when operated at a Parameter A value of _____ and [specify different process operating conditions]. *(Note that this example statement of performance assumes a single significant parameter, A. Additional parameters may be required for a particular technology.)*

VERIFICATION OF PERFORMANCE

Verification testing of TECHNOLOGY NAME was performed from ______ through _______, at an installation on a natural-gas-fired combustion source in State or Region. The results are given in Table 2.

TECHNOLOGY NAME

Table 2. NO_x control performance

Parameter A	Parameter B	Parameter C	Mean Outlet NO_x Concentration ppmv	Half-Width of 95% Confidence Interval on Mean Outlet NO_x ppmv

The APCT quality assurance (QA) Officer has reviewed the test results and quality control data and has concluded that data quality objectives given in the generic verification protocol and test/QA have been attained.

During the verification tests, EPA and/or APCT quality assurance staff conducted technical assessments at the test laboratory, which confirm that the verification test was conducted in accordance with the test laboratory's EPA-approved test/QA Plan.

This verification statement verifies the NO_x emissions characteristics of TECHNOLOGY NAME within the stated range of application. Extrapolation outside that range should be done with caution and an understanding of the scientific principles that control the performance of TECHNOLOGY NAME. Users with NO_x control requirements should also consider other performance parameters such as service life and cost when selecting a NO_x control system.

In accordance with the generic verification protocol, this verification report is valid commencing on DATE indefinitely for application of TECHNOLOGY NAME within the range of applicability of the statement.

_____ _____

E. Timothy Oppelt Date
Director
National Risk Management Research Laboratory
Office of Research and Development
United States Environmental Protection Agency

Jack R. Farmer Date
Program Manager
Air Pollution Control Technology Program
Research Triangle Institute